

Enchytraeids (Oligochaeta) in an Austrian spruce forest: abundance, biomass, vertical distribution and re-immigration into defaunated mesocosms

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Abstract

In an Austrian spruce forest, enchytraeid abundance, biomass, vertical distribution, dominance structure, and re-immigration into defaunated mesocosms were determined after an exposition period of eight months. With the exception of biomass, no significant differences compared with the control area were observed. In June 1992, the average enchytraeid abundance amounted to 30 274 [15 255 S.D.] individuals m^{-2} , the biomass reached values of up to 8.99 [4.21 S.D.] g fresh mass m^{-2} . Four species were found: *Cognettia sphagnetorum* made up about 90% of the enchytraeid fauna, with 83% occurring in the L+F-layer. *Cognettia clarae* preferred the H-layer, where more mature worms were found. The biomass of *Mesenchytraeus pelicensis* was greater in the L+F-layer. *Marionina clavata* occurred in the forest soil in small numbers and showed no differences in colonization of the two horizons.

Keywords: Enchytraeidae, Oligochaeta, *Cognettia sphagnetorum*, spruce forest, mesocosms.

Les Enchytréides (Oligochaeta) d'une forêt d'Épicéas autrichienne : abondance, biomasse, distribution verticale et recolonisation de mésocosmes défaunés.

Résumé

L'abondance, la biomasse, la distribution verticale et la structure du peuplement d'Enchytréides d'une forêt d'Épicéas autrichienne ont été étudiées en analysant au bout d'une période de 8 mois la recolonisation de mésocosmes préalablement défaunés. Aucune différence significative n'a été observée entre le témoin et les mésocosmes, excepté en ce qui concerne la biomasse. En juin 1992, l'abondance moyenne des enchytréides était estimée à 30 274 (15 255 SD) individus m^{-2} , et leur biomasse était supérieure à 8,99 (4,21 SD) g. m^{-2} (poids frais). Le peuplement était composé de quatre espèces: *Cognettia sphagnetorum* constituait plus de 90% du peuplement, 83% étant localisé dans la couche L+F de la litière. *Cognettia clarae* montrait une préférence pour la couche H où l'on a trouvé davantage de vers matures. La biomasse de *Mesenchytraeus pelicensis* était plus importante dans la couche L+F. *Marionina clavata* était présent en petit nombre dans le sol forestier et ne montrait pas de différence de colonisation significative entre les 2 horizons de litière.

Mots-clés : Enchytréides, Oligochètes, *Cognettia sphagnetorum*, forêt d'Épicéas, mésocosmes.

INTRODUCTION

Terrestrial enchytraeids are very abundant in acid forest soils rich in organic matter (up to 300 000 ind. m⁻²). In Scandinavian coniferous mor humus soils only one species, *Cognettia sphagnetorum*, contributes 90–100% to the total enchytraeid fauna (O'Connor, 1957; Nurminen, 1967; Abrahamsen, 1972), making up a considerable portion of animal biomass and respiration. The almost 100% dominance of this species is apparently due to its asexual reproduction by fragmentation. This ability might be advantageous for the rapid recolonization of the soil after dry periods (Lundkvist, 1982) and is supported by the reactivated microflora.

Litter overgrown by microorganisms is reported to be the essential food of *Cognettia sphagnetorum* (Springett, 1964; Latter and Howson, 1978). Recent investigations pointed out the important role of these worms in litter decomposition (Römbke, 1991) and nutrient mobilization (Abrahamsen, 1990). In an Austrian spruce forest, where *Cognettia sphagnetorum* is also the dominant species, mesocosm studies aim to determine the mesofaunal impact on microflora and nutrient dynamics. Microbial biomass and activities in soil monoliths with and without mesofauna were compared under nearly undisturbed conditions (Kandeler *et al.*, 1994). In this paper, the re-immigration of enchytraeid species into defaunated mesocosms is presented in terms of abundance, biomass, dominance structure, and vertical distribution.

MATERIALS AND METHODS

The investigations were carried out in a 40-year-old spruce forest (*Picea abies* L.) without undergrowth in Raumberg (Gumpenstein), Styria, Austria (47°29'N/14°07'E, 730 m a.s.l.). The soil is a dystric cambisol (FAO) over quaternary sediments (silty sands) with a mor humus layer. The litter-plus-humus-layer reaches a thickness of 15 cm. The L+F-horizon contains 84% organic matter, with a pH of 3.2 (0.01 M CaCl₂, 1: 2.5), the H-horizon 73%, with a pH of 2.8 (Kandeler *et al.*, 1994).

For partial defaunation, 30 soil monoliths (25 × 25 cm surface area, 15 cm depth) were frozen to -15°C, measured at the center of the block. The duration of freezing took 4–6 hours. As proved by previous tests, the meso- and macrofauna was killed off at this temperature. The monoliths were frozen one time. Four different experimental sets of mesocosms were exposed from October 1991 to June 1992 (Methods: Kampichler *et al.*, 1994): (1) 10 soil monoliths frozen and wrapped with nets of fine mesh size (35 µm) to exclude meso- and macrofauna; (2) 10 soil monoliths frozen and wrapped with nets of coarse mesh size (1 mm) to

exclude only macrofauna; (3) 10 soil monoliths frozen and unwrapped; (4) undisturbed soil, control area.

The dimensions of the mesocosms and the interdisciplinary approach allowed only one sampling date with respect to enchytraeid re-immigration. After the exposition-time of eight months, 10 samples were taken from each experimental set using a cylindrical soil corer of 7 cm diameter and 10 cm depth. L+F-layer (2–5 cm thick) and H-layer (5–8 cm thick) were considered separately. The enchytraeids were extracted by the heat wet funnel method (O'Connor, 1962) and identified alive, using the descriptions of Nielsen and Christensen (1959, 1961). Worms were embedded in Marc André II (Dunger and Fiedler, 1989) in order to measure body length and surface area. Body volume was calculated using the formula of Römbke and Kreysh (1988). Individual biomass (fresh mass) was determined by multiplying body volume with a factor of 1.051 (Abrahamsen, 1973a); it may be converted to dry mass by multiplying with a factor of 0.15 (Petersen and Luxton, 1982).

RESULTS

In June 1992, 30 274 [15 255 S.D.] enchytraeids m⁻² occurred in the undisturbed soil of the spruce forest. The biomass amounted to 8.99 [4.21 S.D.] g fresh mass m⁻². Four species were found in the study area (tables 1 and 2). As in comparable Scandinavian coniferous forest soils, *Cognettia sphagnetorum* made up about 90% of the enchytraeid fauna.

Figure 1 shows that all four species re-immigrated into the defaunated soil monoliths. There were only a few enchytraeids in treatment (1). Abundance, dominance structure and vertical distribution in treatments (2) and (3) were almost the same as in the control area (4). However, there are some differences in biomass. In the monoliths treatment (2) and (3) the fresh mass of *Cognettia sphagnetorum* was higher as in the surrounding soil (4). In the H-layer of the mesocosms wrapped with the coarse net (2) most mature *Cognettia clarae* individuals were found. As shown in figure 2, the biomass of this species in these monoliths is about twice as in (3) and (4).

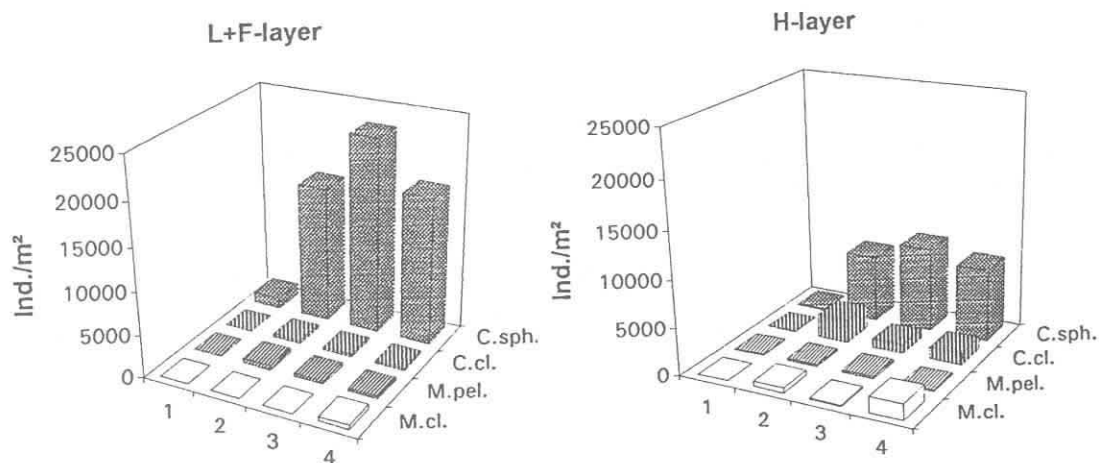
83% of *C. sphagnetorum* colonized the L+F-layer, where this species is dominant in terms of both individuals and biomass (figs. 1 and 2). In the H-layer, *C. sphagnetorum* is also dominant, but, expressed in fresh mass, *Cognettia clarae* contributes the major part of the enchytraeid biomass. It is about three times the length of *C. sphagnetorum* (table 3) and reproduces sexually. Mature worms are only found in spring and early summer (Bauer, 1993). On the sampling date, a great number of sexually mature *C. clarae* individuals were found in the soil samples. In the H-layer, 51% of the individuals had a distinct clitellum, in the L+F-layer only 19%. In the deeper horizon, the *C. clarae* individuals were significantly larger than in the surface

Table 1. – Abundance and individual dominance of the four enchytraeid species occurring in the four experimental sets (1)-(4) in an Austrian spruce forest.

	Abundance/Ind. m ⁻²							
	treatment 1		treatment 2		treatment 3		treatment 4	
	$\bar{x}$ [S.D.]	%	$\bar{x}$ [S.D.]	%	$\bar{x}$ [S.D.]	%	$\bar{x}$ [S.D.]	%
<i>Cognettia sphagnetorum</i>	1 414 [2 152]	94.2	23 062 [13 019]	84.6	31 746 [9 472]	92.7	26 082 [13 506]	86.2
<i>Cognettia clarae</i>	29 [82]	1.9	2 883 [26 09]	10.6	1 703 [1 715]	5.0	1 552 [13 04]	5.1
<i>Mesenchytraeus pelicensis</i>	58 [108]	3.9	753 [720]	2.8	635 [746]	1.9	339 [420]	1.1
<i>Marionina clavata</i>	0	0	572 [1 303]	2.0	144 [178]	0.4	2 301 [2 657]	7.6
	1 501 [2 109]		27 270 [14 565]		34 228 [9 998]		30 274 [15 255]	

Table 2. – Biomass and biomass dominance of the four enchytraeid species occurring in the four experimental sets (1)-(4) in an Austrian spruce forest.

	Biomass/g fm m ⁻²							
	treatment 1		treatment 2		treatment 3		treatment 4	
	$\bar{x}$ [S.D.]	%	$\bar{x}$ [S.D.]	%	$\bar{x}$ [S.D.]	%	$\bar{x}$ [S.D.]	%
<i>Cognettia sphagnetorum</i>	0.66 [0.74]	62.3	6.41 [2.98]	35.4	8.97 [2.71]	58.1	4.45 [2.41]	49.5
<i>Cognettia clarae</i>	0.01 [0.03]	0.9	9.52 [9.53]	52.6	4.61 [3.0]	29.8	3.19 [2.52]	35.5
<i>Mesenchytraeus pelicensis</i>	0.39 [0.79]	36.8	1.99 [2.20]	11.0	1.85 [2.50]	12.0	1.04 [1.23]	11.5
<i>Marionina clavata</i>	0	0	0.18 [0.45]	1.0	0.01 [0.02]	0.1	0.31 [0.34]	3.5
	1.06 [0.86]		18.10 [11.49]		15.44 [4.37]		8.99 [4.21]	

**Figure 1.** – Enchytraeid abundance in the four experimental sets (1)-(4) in the L+F- and H-layer of an Austrian spruce forest. C. sph. = *Cognettia sphagnetorum*, C. cl. = *Cognettia clarae*, M. pel. = *Mesenchytraeus pelicensis*, M. cl. = *Marionina clavata*.

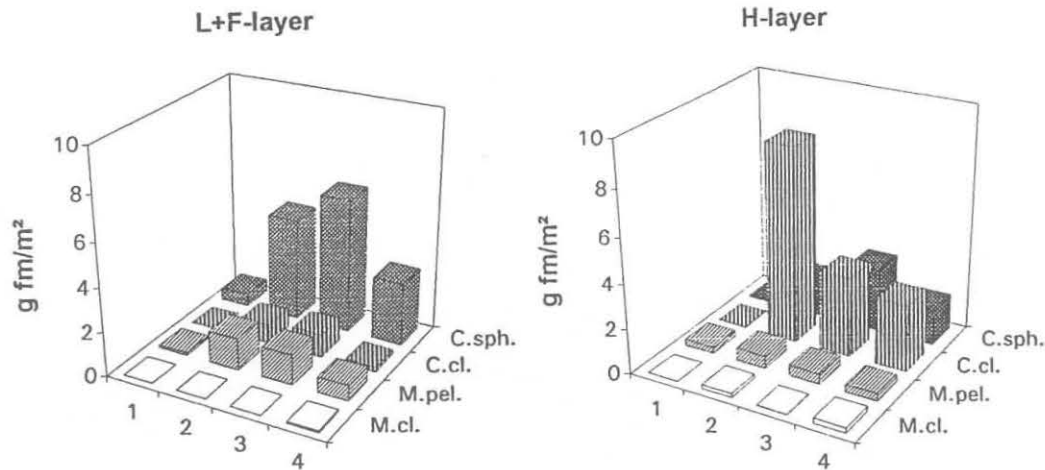


Figure 2. – Enchytraeid biomass (mg fresh mass m^{-2}) in the four experimental sets (1)–(4) in the L+F- and H-layer of an Austrian spruce forest. Abbreviations see figure 1.

Table 3. – Body length and dominance range (individuals and biomass) of the four enchytraeid species found in an Austrian spruce forest.

	Body length (mm)	individual dominance (%)		biomass dominance (%)	
		L+F-layer	H-layer	L+F-layer	H-layer
<i>Cognettia sphagnetorum</i> Vejdovsky, 1877	3.3 ± 1.1 $n = 100$	92-97	50-87	67-74	14-32
<i>Cognettia clarae</i> Bauer, 1993	10.5 ± 3.8 $n = 100$	0-2	10-40	0-13	55-80
<i>Mesenchytraeus pelicensis</i> Niel. and Christ., 1959	7.8 ± 2.8 $n = 57$	2-5	1-10	15-33	4-6
<i>Marionina clavata</i> Niel. and Christ., 1961	3.5 ± 1.4 $n = 100$	0-4	0-15	0-2	0-4

stratum: $\bar{x} = 10.7$ [3.8 S.D.] mm ($n = 176$) in the H-layer and $\bar{x} = 8.6$ [3.4 S.D.] mm ($n = 33$) in the L+F-layer ($\alpha = 1\%$, Student's *t*-test).

Mesenchytraeus pelicensis and *Marionina clavata* showed the same body length and maturity in both horizons. While most of the *M. pelicensis* biomass was found in the L+F-layer, there were no differences in the colonization of the two layers by *M. clavata*. *M. clavata* generally exhibited a low individual abundance in the spruce forest soil; because of its small body size, its contribution to the total enchytraeid biomass is not significant.

DISCUSSION

The present paper is part of a mesocosm study which aims to determine the mesofaunal impact on microflora and nutrient dynamics under nearly undisturbed conditions (Bruckner *et al.*, 1993; Kampichler *et al.*, 1994; Kandeler *et al.*, 1994). For this purpose a new method was developed to obtain soil monoliths having almost the same biotic and abiotic characters as in the surrounding soil, except for the absence or

presence of certain soil animal compartments. One of the questions was whether the enchytraeid composition in defaunated soil monoliths was distinguishable from the undisturbed soil after a period of eight months. Due to the single sampling date temporal and seasonal fluctuations of abundance and biomass were not taken into account. Nevertheless, the results are comparable with enchytraeid communities in coniferous and beech mor humus soils in Scandinavian and German forests (Nurminen, 1967; Abrahamsen, 1972; Lundkvist, 1982; Heck and Römbke, 1990; Römbke, 1991), where *Cognettia sphagnetorum* is also the dominant species. Vertical distribution of enchytraeids depends on humidity and temperature (Springett *et al.*, 1970; Lundkvist, 1982), but may also be species specific. Gröngroft and Miehlich (1983) found that *Cognettia sphagnetorum* mainly lived in the litter layer in Scots pine stands, whereas *Marionina clavata* occupied the deeper and upper horizons. In the investigated Austrian spruce forest, most of the *Cognettia sphagnetorum* individuals inhabited the L+F-layer, where the greatest microbial activities were established (Kandeler *et al.*, 1994). As reported elsewhere, litter overgrown by microorganisms is

necessary for growth and development of this species (Springett, 1964). Feeding activity of these worms may have a considerable impact on microbial activity. As respiration depends on animal body size, most of the enchytraeid metabolism takes place in the upper soil horizon. In an acid beech forest, Enchytraeidae contribute 60% to the total soil animal respiration (Römbke, 1991). Beyond the direct influence of enchytraeid feeding on decomposition processes, it is necessary to assess their indirect impact (for example the direction of microbial processes by grazing or by catalytic effects). Thus, the less abundant species must not be disregarded. To date, only little is known about their ecology and nutrient requirements.

When comparing different enchytraeid species and populations, biomass values often provide a more accurate description of the density than individual number does. Despite the use of various earlier approaches, problems in biomass determination still remain (desiccation of the worms during the weighing process and proportion of the gut content). Römbke and Kreysh (1988) developed a method of measuring, biomass calculation and identification of embedded worms involving only a few steps; this makes ecological investigations of enchytraeids more

practicable. Nevertheless, a higher amount of biomass is calculated by this method than by weighing the worms.

In terms of biomass the different preferences for the two distinguished layers by *Cognettia clarae* and *Mesenchytraeus pelicensis* are clearly evident. While *M. pelicensis* shows the same body length and maturity in both horizons, a greater number of mature and larger *C. clarae* individuals colonizes the H-layer. Unpublished investigations also indicate a phenological difference between the two sexually reproducing species. *M. clavata* is a characteristic species in acid soils, but it occurs only in low densities.

The ability to reproduce by fragmentation is no doubt advantageous for *C. sphagnetorum* in the re-immigration process into the defaunated soil monoliths. It is the dominant species in the mesocosms, but, after a period of eight months, the other sexually reproducing enchytraeid species also occurred there. In the frozen monoliths wrapped with coarse net (2), as well as in the frozen, unwrapped soil monoliths (3), the same dominance structure was observed as in the undisturbed forest soil (4): the characteristic enchytraeid community was established in both cases.

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